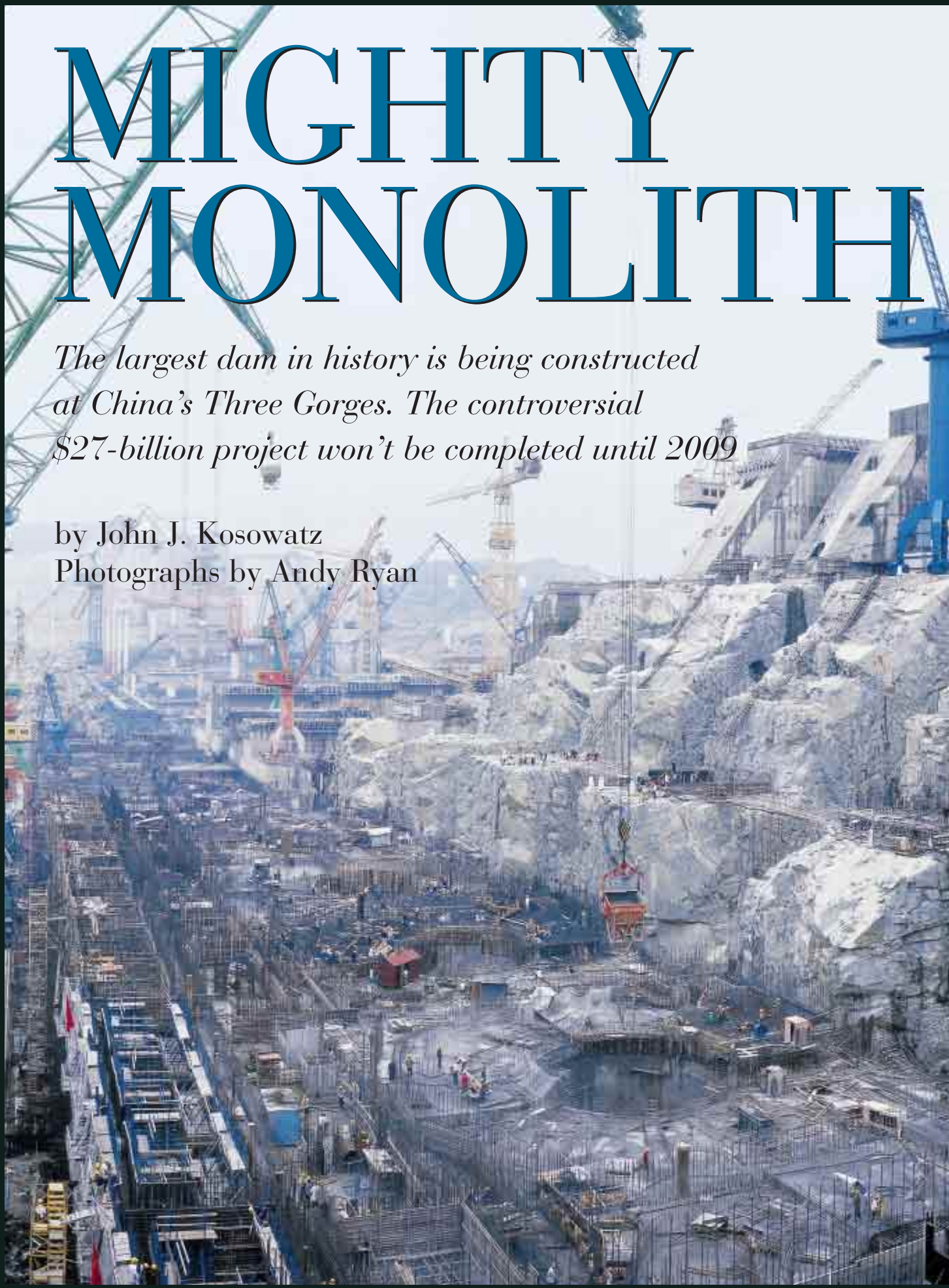
MIGHTY MONOLITH

The largest dam in history is being constructed at China's Three Gorges. The controversial $27-billion project won't be completed until 2009

by John J. Kosowatz
Photographs by Andy Ryan



Three Gorges Dam, summer of 1999

The setting could hardly be more dramatic: a long stretch of the Yangtze River slicing through the fabled Three Gorges, a breathtaking region steeped in history and culture, with relics and records to the dawn of Chinese civilization. Against this stunning backdrop, the world's biggest, most expensive—and most controversial—construction project is under way.

When completed in 2009, the Three Gorges Dam will be a concrete monolith of mind-boggling proportions: 60 stories high and 1.4 miles (2.3 kilometers) long. The record-shattering $27-billion project will block the Yangtze to impound a narrow, ribbon-like reservoir longer than Lake Superior. Twenty-six monstrous turbines will generate 18,200 megawatts, roughly the output of 18 nuclear power plants.

The megastructure may mark the end of an era that began during the Great Depression at Hoover Dam in the U.S. Today many prime sites for large dams have already been developed or are protected, and rising concerns over the environmental and social impact of such structures, combined with their tremendous monetary cost, effectively scuttle development.

China has bucked the trend, shrugging off stiff domestic and worldwide criticism. With the country's most famous and controversial project at stake, Beijing has put engineers and managers on notice. The challenge now is to keep to a schedule so ambitious that workers must break every known record for concrete construction.

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The Furious Flow of Concrete

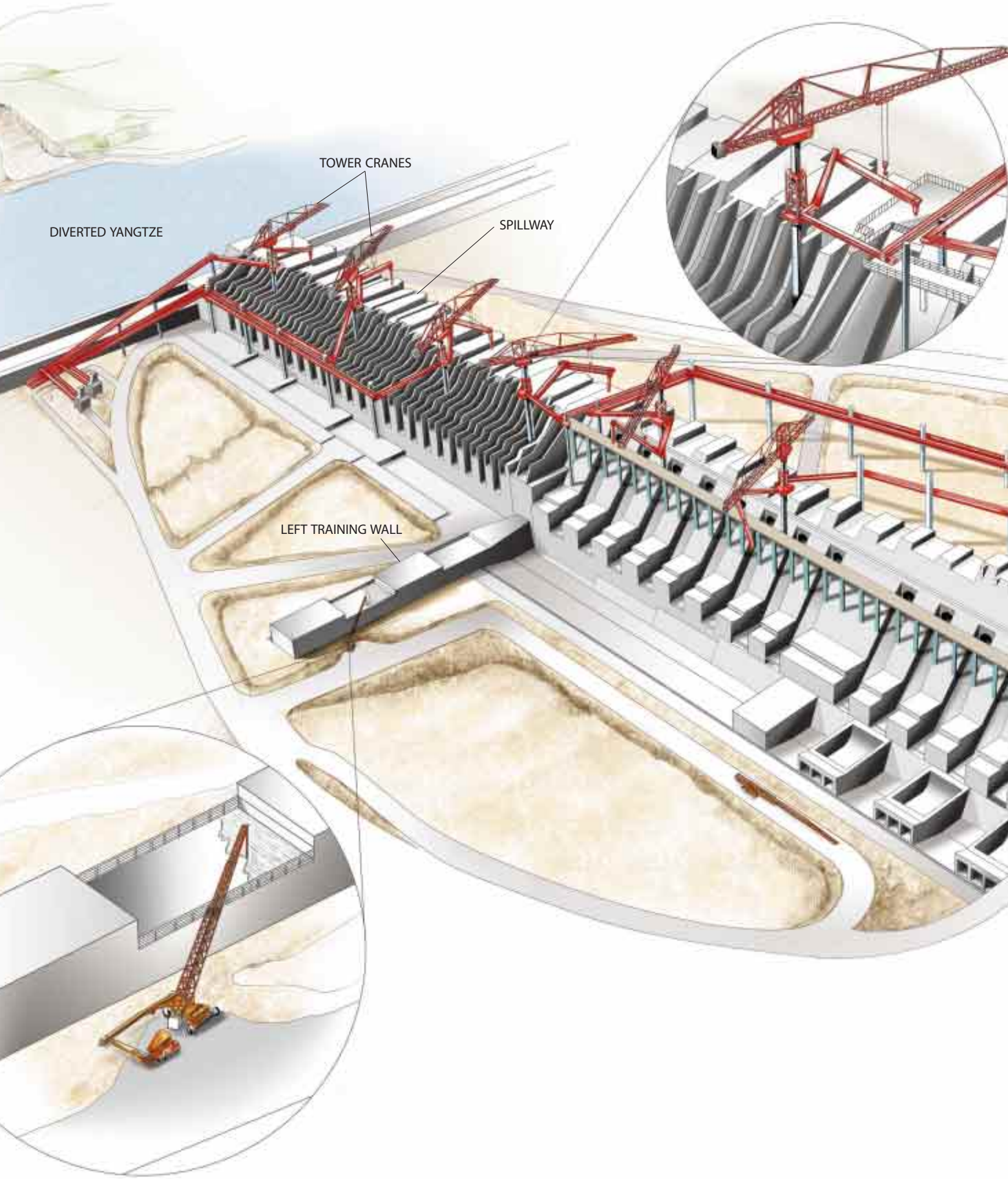
Over the next several years, some 25,000 workers will be swarming over the 3,700-acre (15-square-kilometer) construction site to complete the second of three phases of the Three Gorges Dam [*see illustration on page 20*]. This critical stage presents perhaps the megaproject's biggest challenge: keeping to an aggressive schedule while constructing the dam's spillway and left intake structure, which will house 14 giant turbines (*below*). To meet deadlines, workers must pour concrete at a staggering pace (some 520,000 cubic yards [400,000 cubic meters] per month), requiring an extensive and complex system for transporting the material from the mixing plants.

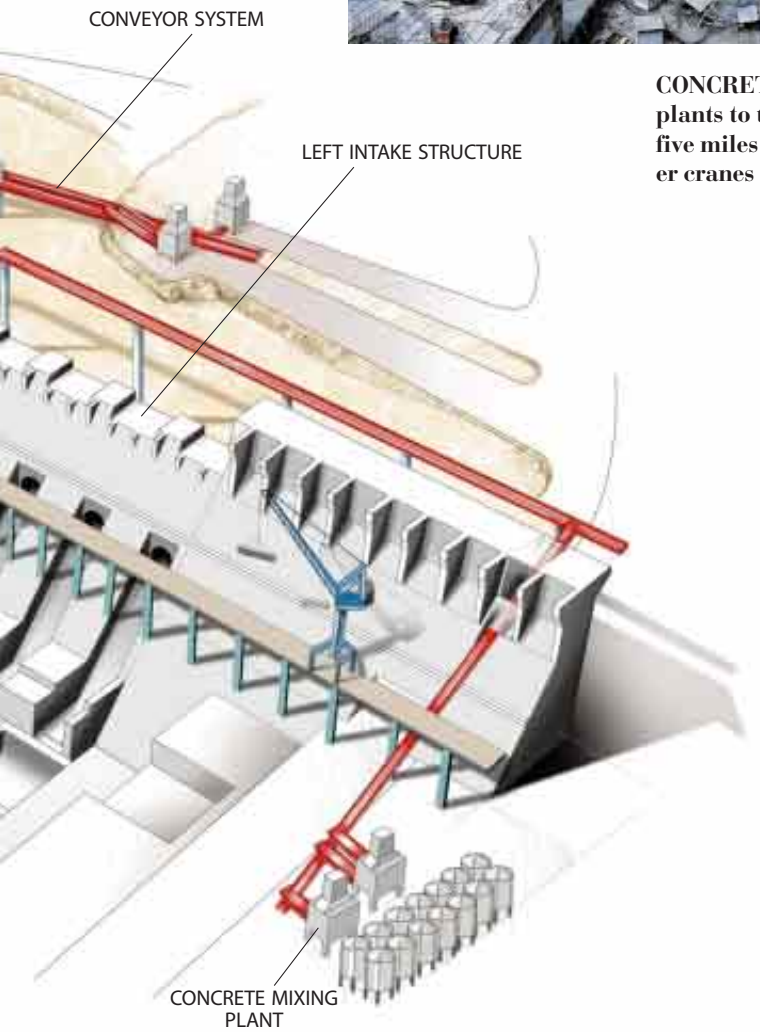
The equipment, from U.S. supplier Rotec Industries, consists of about five miles of movable and rotating conveyors. As the dam grows taller, progressing to its eventual height of 607 feet, six tower cranes specially fitted with jacking systems will raise the conveyors. The illustration at the right shows how the site should look in about a year. In addition to their lifting capacity, the tower cranes (*inset at right top*) have swinging telescopic conveyors that are designed to pour concrete at the impressive rate of more than 600 cubic yards per hour. A mobile crane (*inset at right bottom*) will deliver concrete from a large hauler to construct the dam's left training wall.

Transporting enormous quantities of concrete is one thing; curing it is another. Because concrete generates considerable heat as it sets, large volumes can become exceedingly hot, damaging the material's structural strength. Recently, amid a national crackdown on shoddy construction practices in China, French and U.S. quality experts were hired to monitor the placement of the concrete, which must be kept at a cool 45 degrees Fahrenheit (seven degrees Celsius) as it hardens.

ILLUSTRATION BY DANIELS & DANIELS

FEEDING THE TURBINES: Huge water intakes (*left*) will divert water from the Yangtze River to one of 26 gigantic turbines. At full capacity the dam will generate 18,200 megawatts, making it the biggest hydropower producer in the world. The intakes are placed about halfway up the dam's eventual 60-story height (*below*).





CONCRETE DELIVERY: Transporting concrete from the mixing plants to the dam requires a complex and extensive system of about five miles of fast conveyors (*above*). This equipment is raised by tower cranes as work progresses and the dam grows continuously taller.

GIGANTIC LOCK: Matching the dam in scale, an enormous five-step lock (*right*) is being carved from granite on the river's left bank. The chambers of the lock will be lined with concrete, and when completed it will lift 3,300-ton ships 285 feet, making it the largest such system in the world.

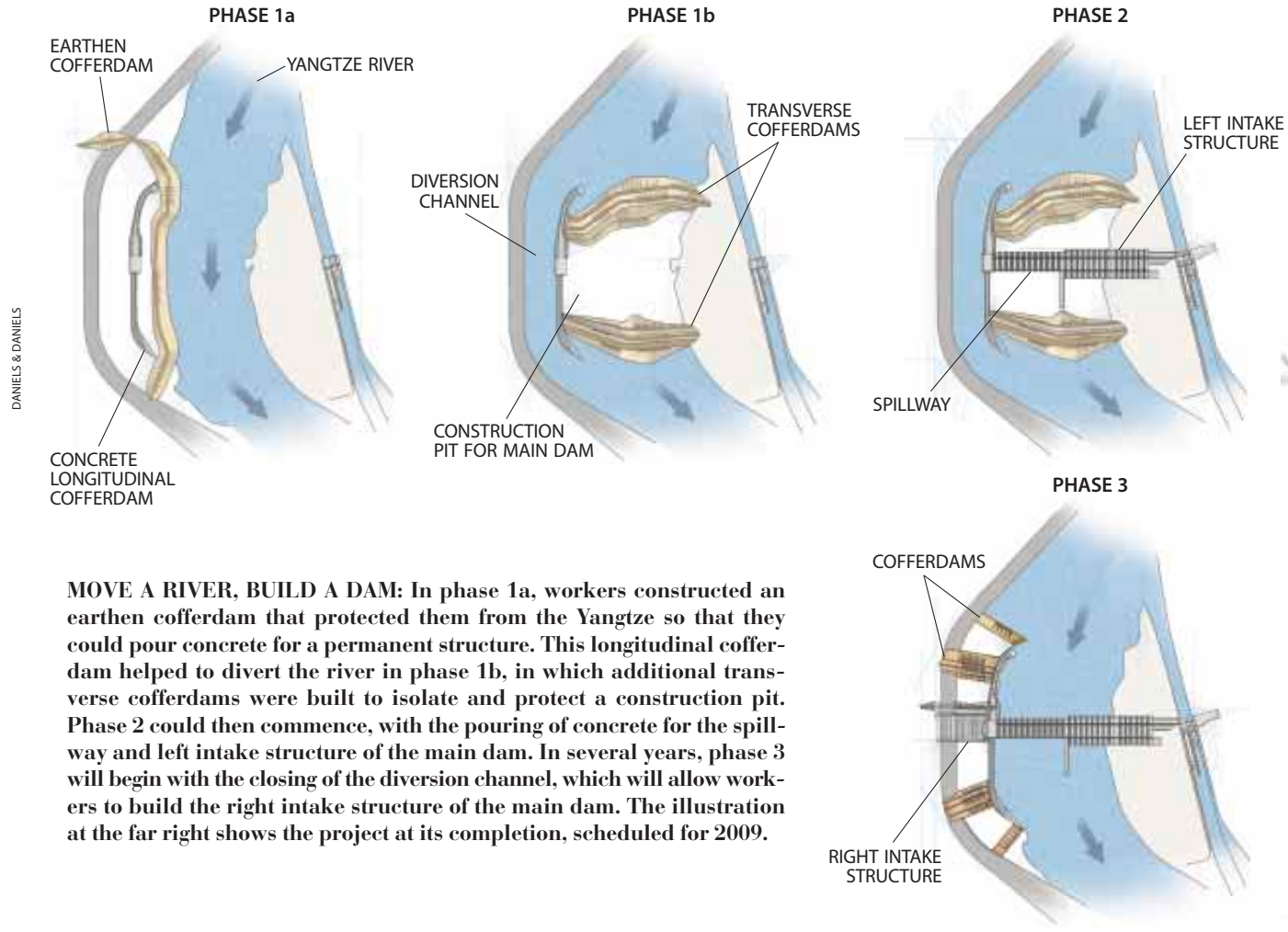
One Dam, Three Phases,

Perhaps no dam in history has been studied to the extent of the multibillion-dollar structure currently rising across the middle reaches of the Yangtze River. Preliminary site investigations for the Three Gorges Dam began in the 1920s, with support from China's prewar government. Later none other than communist leader Mao Tse-tung would champion the project, and from 1958 the first of many detailed geologic studies enabled the present design to take shape. After considering more than a dozen possible sites, engineers selected a wide stretch at Sandouping near the head of Xiling (the easternmost of the Three Gorges) because of the location's abundant granite, deemed ideal for the dam's foundation.

To facilitate transporting thousands of workers to the construction site, the government built a four-lane highway from Yichang, the nearest city of significant size. By any standard, the $110-million road, which cuts through the mountains that frame Xiling, was itself a considerable undertaking: 40 percent of its total length of 17 miles consists of bridges and tunnels, including a twin bore that is more than two miles long. Additionally, a 2,950-foot suspension bridge, the longest in China outside of Hong Kong, was built at Sandouping for access to the project's right bank.

At the dam site, massive earthmoving dominated the first of three major phases, which commenced in 1994. An important goal was the diversion of the Yangtze to enable the later construction of the main dam. First, a large, temporary earthen cofferdam was built along the right bank (*below*). This barrier protected workers from the river as they poured the concrete for a permanent cofferdam. The large longitudinal structure (4,000 feet long and 460 feet high) now defines the Yangtze diversion channel and will eventually be tied into the main dam.

Next, workers built transverse cofferdams both upstream and downstream to clear and protect an area that would become the construction pit for erecting the main dam. The pit was dug to a depth of 260 feet, allowing the foundation work to begin. Numerous holes (with a total length of more than 60 miles) are currently being drilled into the ground and filled with pressurized grout. This "grout curtain" will help protect the main



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MOVE A RIVER, BUILD A DAM: In phase 1a, workers constructed an earthen cofferdam that protected them from the Yangtze so that they could pour concrete for a permanent structure. This longitudinal cofferdam helped to divert the river in phase 1b, in which additional transverse cofferdams were built to isolate and protect a construction pit. Phase 2 could then commence, with the pouring of concrete for the spillway and left intake structure of the main dam. In several years, phase 3 will begin with the closing of the diversion channel, which will allow workers to build the right intake structure of the main dam. The illustration at the far right shows the project at its completion, scheduled for 2009.

Decades in the Making

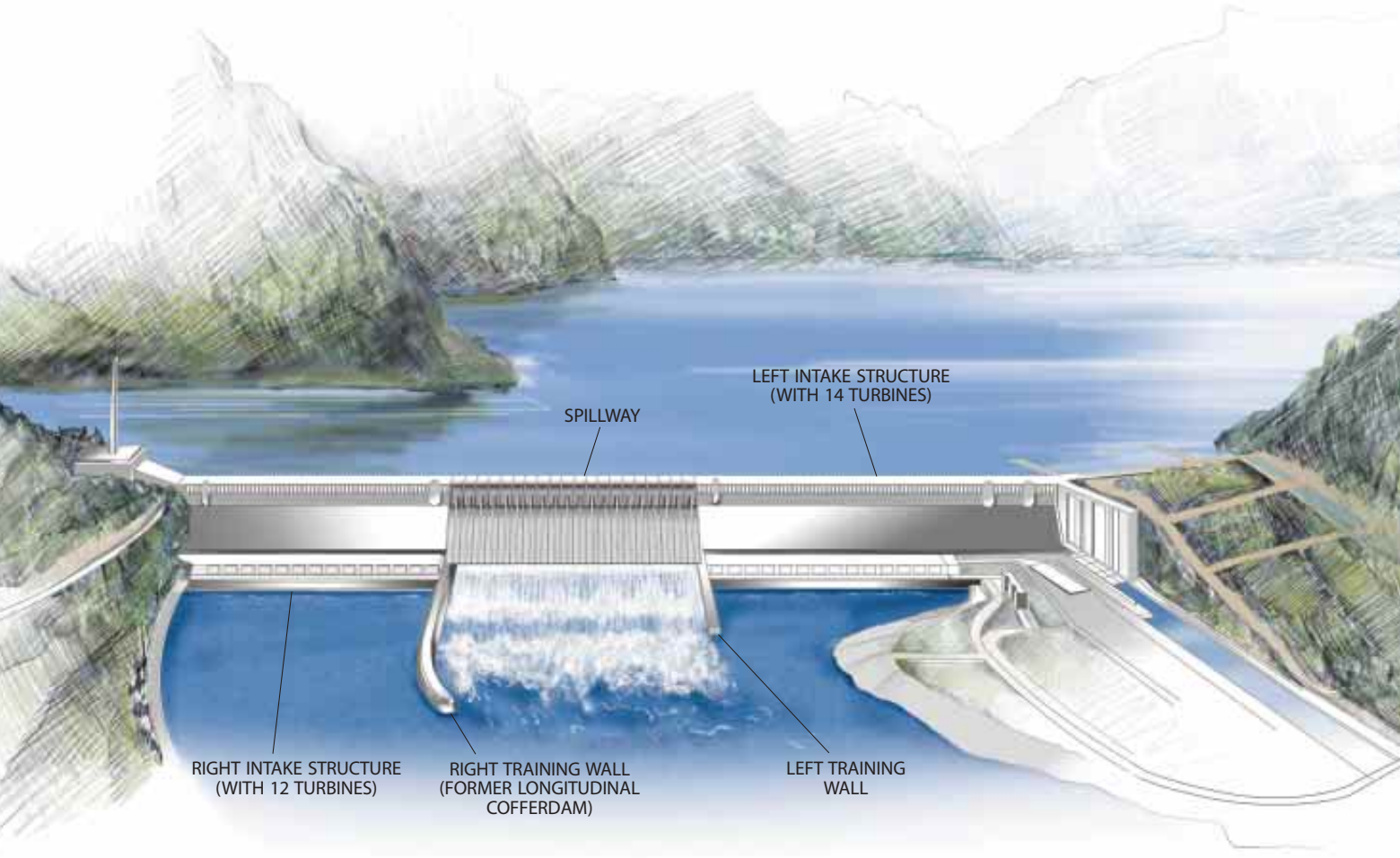
dam from uplift by preventing water from seeping underneath the structure. (For the same purpose, 870,000 square feet of concrete walls were sunk below the transverse cofferdams.)

All told, diverting the Yangtze required about 60 dredges and a huge equipment fleet (oversize trucks, bulldozers and shovels) to place 13 million cubic yards of material. Some of that matter came from excavation of the project's gigantic five-step lock on the left bank (*not shown in these illustrations*). To carve space for the multiple chambers of the lock, workers had to blast with precision more than 75 million cubic yards of hard rock. Because the lock will not be completed for years, a smaller temporary lock and a ship lift were completed along the left bank for moving traffic upriver. (Travel downriver occurs along the diversion channel.)

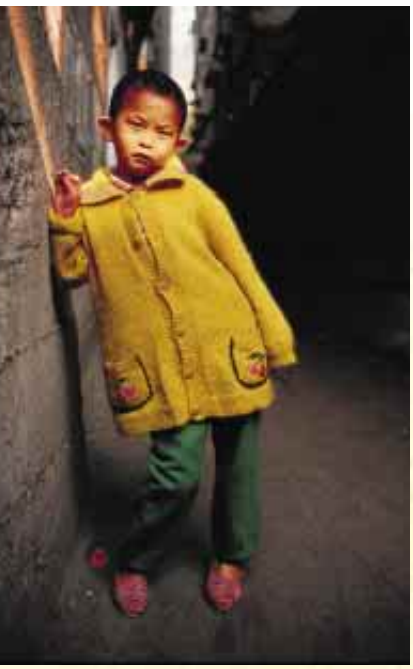
Speed in completing the river diversion and transverse cofferdams was critical. Fearing that the unpredictable Yangtze might flood the site, government officials pushed contractors to finish within one dry season. In November 1997 the river was diverted (before an audience that included President Jiang Zemin), and the transverse cofferdams were completed five months later. The work was essentially finished when the heavy rains arrived in the summer of 1998. The resulting floodwaters caused severe damage along the middle and lower reaches of the river, but at the construction site the cofferdams easily handled the peak flow of 80,000 cubic yards per second.

In the current activity of phase 2, concrete is being poured for the spillway and left intake structure of the main dam. The schedule calls for the first two turbine generators to be producing power—and critical revenue—by 2002, followed by the remainder of the bank in 2003. Phase 2 will also mark the completion of the five-step lock, which will lift ships 285 feet, making it the largest such system in the world.

Years from now, in the third and final phase of the project, laborers will close the diversion channel by building several earthen cofferdams. Construction will then progress on the right intake structure of the main dam, including the powerhouse that will contain the remaining 12 turbines. If all goes according to schedule, the Three Gorges Dam will be completed in 2009 (*below*), marking decades since the preliminary site studies.



An Uncertain Future



Child in Wushan

Every megaconstruction project has elicited controversy, and the Three Gorges Dam is no exception. Proponents assert that not only will the dam generate a tremendous amount of "clean" energy (that is, electricity without the burning of fossil fuels), it will also help control catastrophic flooding along the heavily populated middle and lower reaches of the Yangtze, the world's third longest river. But critics argue that the project's overall toll will far outweigh its potential benefits.

The Three Gorges Dam will increase the water level of the Yangtze for some 370 miles upstream, affecting the habitat of various wildlife, including a rare species of river dolphin, and forcing the relocation of up to two million Chinese living in what will become a reservoir. In fact, nearly half the project's monstrous multibillion-dollar price tag is being applied to the resettlement of hundreds of villages and towns along the river's edge. Although government officials acknowledge this tremendous hardship, they insist that the new apartments and towns being constructed on higher ground will improve the lives of many.

Opponents of the project also contend that silt will accumulate upstream (perhaps even affecting Chongqing, at the reservoir's opposite end) and that the buildup could eventually threaten the dam's stability. Engineers have therefore designed inlets through the structure, where sediment can be flushed downstream during the flood season. But the efficacy of this solution is—like so many other issues concerning the dam's impact—a subject of vigorous debate.

YUNANZHEN

YUNYANG

WANXIAN

Yangtze River

WULINGZHEN

ZHONGXIAN

FENGDU

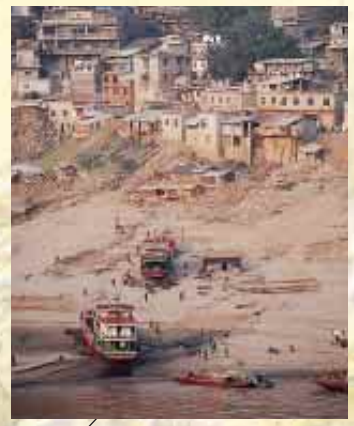
CHANGSHOU

FULING

CHONGQING

INCREASED COMMERCE: The reservoir created by the Three Gorges Dam will end at Chongqing (*left*). One goal of the project is to enable much larger ships to reach this urban center from Shanghai and other intermediate points, ushering in a new age of commerce in central China.

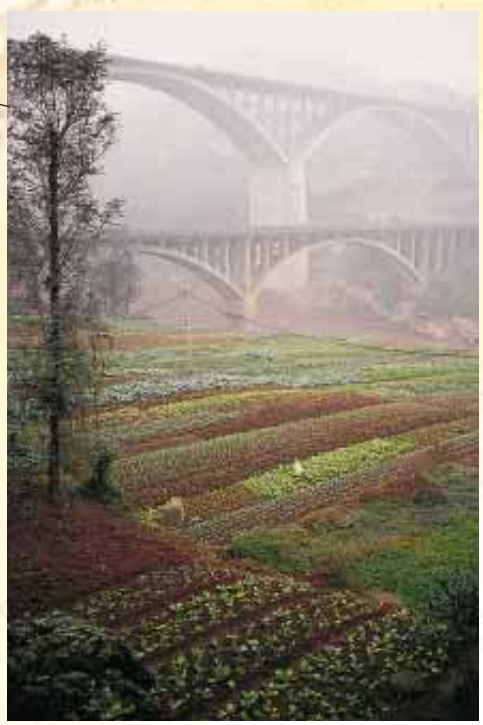
COLLATERAL DAMAGE: Hundreds of rural towns and villages will be inundated by the reservoir waters. Among the countless casualties will be this beautiful public park in Fengdu (*right*).



SHIFTING ECONOMICS: On this beachhead in Yunyang (*left*), workers repair and repaint boats for travel on the Yangtze. With the construction of the Three Gorges Dam, the resulting reservoir will engulf the beachhead, forcing a shift in the livelihoods of many inhabitants of the town.

GORGEOUS GORGES: The Three Gorges Dam is named after three breathtaking canyons—Qutang, Wu and Xiling—that will be forever changed with the project's completion. One estimate is that the waters in Wu Gorge (*below*) will rise by some 300 feet.

FERTILE LANDS: Agriculture has been the mainstay for untold generations in Zhongxian. These two bridges (*below left*) indicate the difference in water level before and after the dam has been built. In addition to being fertile, Zhongxian is rich with artifacts of archaeological significance, some of which have been taken for granted. These ornamental bricks from the Ming dynasty (*above left*) were unearthed by a farmer who used them to build an enclosed structure for his pigs.



TO SAVE A TEMPLE: The Yangtze Valley is home to thousands of archaeological sites, many dating as far back as the Neolithic. The Chinese government recognizes the need to move historic structures, such as this mausoleum in Zigui (*above*), to higher ground, but critics contend that insufficient time and funds remain to salvage China's precious past.

MAP BY SUSAN CARLSON; INSET MAP BY SARAH L. DONELSON